preparing the student for the study of principles, the first of the two objections urged against metallurgical laboratories, that education should be in principles rather than in practice, falls to the ground.

The second objection, that the conditions of actual practice cannot be reproduced in the laboratory would be unworthy of notice, were it not offered by men of such weight that even their errors must be considered.

The error lies in supposing that this instruction aims to anticipate practice in commercial establishments: whereas its aim is to facilitate instruction in metallurgical principles by lectures and text-books. There is no more reason for reproducing commercial practice exactly in the metallurgical laboratory than for reproducing in the chemical laboratory the system of kilns, towers and leaden chambers of the sulphuric acid works. But even from this mistaken point of view the objection is without weight. With equal force it can be urged that fire drill and military drill are useless, because they cannot reproduce exactly the actual conflagration, and the actual carnage and confusion of battle.

Another and important work of the metallurgical laboratory is to give a certain skill in the use of the instruments of precision of the art, in pyrometry, colorimetry and the microscopy of metals and alloys. It seems to me nearly as imperative that the metallurgist's diploma to-day should imply this skill as that the civil engineer's should imply skill in the use of the transit.

Finally, just as into a barrel full of potatoes a quarter of a barrel of sand can be poured, and then a quarter of a barrel of water, so after the student's power of study and note-taking in lectures has been thoroughly utilized, he still has power for much of this different, this observational and administrative laboratory work, in which he absorbs and assimilates priceless information like a sponge, and acquires along the path of least resistance and with but little mental effort the needed metallurgical conceptions.

HENRY M. HOWE.

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*A NEGLECTED FACTOR IN EVOLUTION.**

AN eminent Swedish zoologist, Dr. G. Adlerz, in a very suggestive paper† has recently called attention to some hitherto neglected conditions affecting the variability of organisms. Starting from the high degree of variability which has long been known to obtain in organisms in a state of domestication, Dr. Adlerz directs attention to the similar phenomena presented by wild animals during the great periodic increases in numbers brought about by unusually favorable trophic and meteorologic conditions.

In regard to the domestic organisms Dr. Adlerz gives expression to very generally accepted views when he says: "The changed conditions to which animals and plants are subjected in a state of domestication must, of course, mean a decided mitigation or even a complete cessation of the struggle for existence. They are provided with better and more abundant food than in the feral state and the survival of offspring is better insured. On the whole therefore the individual organisms are able to grow up under the most favorable circumstances.

"No matter how completely the germ-plasma may be shielded from external influences, it must, nevertheless, be susceptible to changes in the kind and amount of food, as Weismann admits, though he appears to lay little stress on this matter. If, as seems probable, variations are ultimately the resultants of physico-chemical processes in the germ-cells, it would seem to be very

* Contributions from the Zoological Laboratory of the University of Texas, No. 33.

† 'Periodische Massenvermehrung als Evolutionsfaktor,' *Biol. Centralbl.*, 22. Bd., No. 4, Feb. 15, 1902, pp. 108–119.

obvious that more abundant food must be responsible for the greater variability of domestic races. The organs, which in the feral state are continually exercised in a severe struggle for existence (in seeking food, pursuing prey, eluding enemies, in addition to other energy-consuming activities), do not under domestication compete so closely with one another for the less needed nutriment. Hence organs like the reproductive glands, which are not so directly implicated in self-preservation, are able to avail themselves of more food, and this should make possible, among other things, more numerous combinations of the varying elements. That greater abundance of food is thus one of the most potent, though indirectly effective, causes of variability in domestic races, may be regarded as an established fact, in so far as we are able to be certain of anything relating to this matter. It is a fact that the variability of these races in comparison with the conditions in a state of nature, has been enormously increased, and it would be difficult to point to any other factor in domestication of such decisive importance to the organism as surplus of food."

As Adlerz suggests in his paper, wild animals present certain peculiarities analogous to those exhibited by domesticated forms, viz., in the enormous numerical increase of periodic occurrence in many if not in all species. This increase must depend on conditions similar to those which produce a high rate of variability in domestic forms, *i. e.*, abundance of food and favorable meteorologic conditions. We should therefore expect to find a greater amplitude of variation as well as a greater number of individual variations during such increases than during periods of more limited increase. This is supported by the facts, as shown by Adlerz's observations on two such numerical increases in a butterfly (*Polyommatus virgaureæ*):

"These two increases in number were observed in the province Medelpad in central Sweden. The first occurred in 1896. That year the butterflies were seen to increase greatly during July till, by the middle of the month, they outnumbered all the remaining species of diurnal Lepidoptera. At the same time were observed a great number of a female variety not to be found in any other part of the country. This variety was distinguished by a series of light blue spots within the reddish-yellow band across the upper surface of the hind wings. The number and clearness of the spots varied greatly. The highest number was five, and from the varieties with the full number clearly developed, to the individuals of the dominant form, which had no spots at all, an uninterrupted series of transitional variations could be established.

"During the following year the species was not conspicuously abundant. Single individuals of the above described variety also appeared, but *they were both absolutely and relatively much rarer than among the increased number of the previous year.* Moreover, *no such marked variations were seen as on that occasion.* Hence the statement that *the amplitude of variation during 1896 was greater,* would appear to be admissible.

"During the past summer, 1901, the same species of butterfly reappeared in great numbers, and again, as in 1896, during the latter half of July the number of individuals was seen to exceed that of all the other diurnal Lepidoptera. And again the above-mentioned variety appeared in great numbers. By counting all the females among the numerous individuals that had settled on several large tansy patches, I found that many more than half showed the variation in question to a greater or less extent.

"These two numerical increases thus support the conclusion derived from theoretical

considerations, that during the increase of a species both the absolute and relative number of varying individuals as well as the amplitude of variation are increased beyond what is usual.''

The opponents of natural selection have often implied that conclusions drawn from domesticated animals cannot be used to explain the origin of varietal and specific forms among animals living under natural conditions. These authors seem tacitly to assume that the conditions of domestication are unique in that they can be realized only in human surroundings and under conscious human control. This, however, is not the case. The social Hymenoptera among insects, notably the ants, not only exhibit a form of domestication, as I shall endeavor to show, but also a pronounced and regular periodic increase in numbers. Thus they combine both the conditions for producing high variability, and furnish a brilliant illustration of the evolutionary factor to which Adlerz has called attention. Adlerz, who is well known as a myrmecologist, has, of course, utilized the ants to some extent in support of his views. He calls attention to the effects of feeding on the personnel of growing colonies. I believe it is possible in this connection to lay still greater stress on the facts. A considerable number of observations on colonies of different species of *Pheidole* have led me during the past three years to essentially the same views as Adlerz. As these ants beautifully illustrate the union of domestication and numerical increase and a concomitant high degree of variability, it seems best to record some of my observations and reflections in the hope that they may be of interest to those who are undertaking studies in variation.

It is now a well-established fact that every ant-colony is founded by a single fertilized female, or queen. The insect loses her wings and buries herself in a small cavity in the soil or wood that is to form the future nest. After entering the cavity she usually closes the opening so that she is completely shut off from the outside world. She deposits, at the expiration of a certain time, a number of eggs, and when these hatch as larvæ she does not go abroad in quest of food but feeds her offspring with substances regurgitated from her own body. These substances are ultimately derived from the fat body, a store of nutriment accumulated during her life in the maternal nest which she forsook to take the nuptial flight. Of course, the insect must derive her own nourishment from the same internal source and, as in all ants, the development of the young extends over a considerable period of time, it follows that the larvæ are of necessity poorly fed and after pupation hatched as dwarf workers (microërgates). The number, too, of these diminutive creatures is limited, so that the whole colony in this incipient stage is a family consisting only of the huge mother and a few dwarf offspring. These workers, though very timid, forthwith break through the walls of the chamber and establish relations with the outside world, whence they bring food into the nest and feed their half-starved parent. This food soon enables her to lay another batch of eggs, the larvæ from which are now turned over to the care of the workers. Being better fed, the second litter are able to reach a greater size before pupation and therefore give rise to larger workers than their nurses. The number of workers thus reinforced soon brings about a condition of affluence in the colony. The queen is more and more abundantly fed, and this, coupled with her confined and sedentary life, enhances her fecundity. The colony waxes strong in numbers and the workers of successive batches grow larger till they attain to the full stature of the species. Then, and not till then, do the

ants begin to educate the fertile sexes, the males and queens. Enormous numbers of these, in some species hundreds or even thousands, are produced during the most favorable season of the year, and all these individuals are carefully fed, groomed and guarded by the workers till fully mature and ready for the hymeneal flight.

If we look upon the ant-colony as a complex of more or less heterogeneous individuals, comparable to the Metazoan body, which is also a complex of units, the more or less differentiated cells, we may say that the sexual individuals of the ant-colony develop only under favorable trophic conditions, just as the sexual organs of the Metazoan mature only under similar conditions. While this analogy is useful it is also advantageous for present purposes to look at the sexual forms of ants under a somewhat different aspect, viz., as organisms that are educated to maturity in what is essentially a state of domestication. This is obvious when we consider that the males and queens are not only reared from the eggs, but fed, groomed and guarded by the attendant workers throughout their whole imaginal life in the nest. All these attentions vividly recall the attentions lavished by man on the animals of his household. One is especially reminded of this resemblance on seeing the behavior of the workers towards the sexual forms, just before the latter are ready to take the nuptial flight. The males and queens are permitted on successive days to take the air about the entrance of the nest. At such times they are herded by the workers like so many cattle, and hastily dragged or driven into the nest on the slightest suspicion of danger.* The fostering instinct which, in the ant colony, envelops both the mature forms and the young of all descriptions, constitutes the basis from which myrmecophily and the various forms of symbiosis in general have been developed. The extraordinary development of this fostering instinct is demonstrated by the interesting fact that no less than 1,500 species of Arthropoda are now known to live with the different species of ants on terms of amity or toleration.

The sexual individuals, when finally liberated from the nest, are thrown entirely on their own resources, and for a time the struggle for existence sets in with great severity. One has an opportunity of actually witnessing both catastrophic and personal elimination often on a magnificent scale. The struggle among the males for the possession of the females is intense. The lives even of the fortunate among the former are rapidly extinguished. The surviving, fecundated queens set to work to establish their colonies, an arduous and complicated undertaking which ruthlessly eliminates all the poorly equipped. Even before they can dig their nests hundreds of these insects are devoured by birds, lizards, spiders, etc. And many more of them die from exhaustion while digging their nests, or from hunger while raising their first litter of young, or from the attacks of subterranean predatory insects, parasitic fungi, etc. This struggle, however, terminates on the appearance of the first workers, and the successful queens thenceforth again lapse into a condition of domestication till the close of their often very long lives. These general statements concerning the formation and growth of the colony will apply to most if not to all ants.* They

* I have seen beautiful instances of this in the Texan agricultural ant (*Pogonomyrmex barbatus* Smith var. *molifaciens* Buckley) and in our northern species of *Lasius*.

* In a former paper ('The Habits of *Ponera* and *Stigmatomema*,' *Biol. Bull.*, Vol. II., No. 2, Nov., 1900, p. 68) I maintained that the Ponerinæ perhaps constitute an exception to the general method of establishing colonies, but I have recently found in a small cavity in a stone a fertile deälated queen of *Odontomachus clarus*

will also hold good to a considerable extent of the social wasps and probably also of the termites. The colonies of the former, however, are of annual instead of perennial growth like those of ants and termites. This is a difference of no little importance from the standpoint of our discussion, since it is readily seen that the conditions prevailing among ants and termites must tend to develop and strengthen the domesticating instinct to an extraordinary extent. This is indicated by the host of known myrmecophiles and termitophiles as contrasted with the few guests and parasites known to live in the nests of wasps.

The dependence of variability on the age and trophic status of the colony is most clearly seen in ants that have polymorphic workers. The huge, cosmopolitan genus *Pheidole, e. g.,* is particularly interesting in this respect. Its species are characterized by having workers of at least two very different aspects: minute, small-headed workers proper, and huge-headed soldiers, often of monstrous aspect. In a few American species (*P. instabilis* Emery, *carbonaria* Pergande and *vaslitii* Pergande) these two forms are connected in the same nest by perfect series of intermediates. In the vast majority of species, however, such transitions are very rare or altogether wanting. The queens of *Pheidole* are much, the males but little, larger than the soldiers.

The soldiers are put to different uses by different species. In the grain-storing species they function as the official seed-crushers of the community. The diminutive workers collect the seeds and store and move them about in the chambers of the nest. They are, however, quite unable to break the hard shells, which yield only to the powerful jaws of the soldiers. In the carnivorous species the workers bring in pieces of insects, while the soldiers act as trenchers and sever the hard, chitinous joints. In the above-mentioned American species with polymorphic workers, I believe that the transitional forms may also be of use to the colony as seed-crushers and trenchers, since the vegetable and animal food is of different degrees of hardness and the work of making it accessible is not thrown on a single caste as it is in the strictly dimorphic forms. In some species the soldiers undoubtedly deserve their name, for they run about with wide-open mandibles and attack any intruder with great fury. In other species they are very timid and make for the concealed chambers as soon as the nest is disturbed. They thus manifest an instinct which is highly developed in the sexual forms, especially the queens, whom the soldiers also resemble in certain morphological characters more closely than they do the workers.

Under ordinary conditions only the workers of *Pheidole* go abroad, while the soldiers remain at home and very rarely stray beyond the entrance of the nest unless the whole colony is moving to a new home.*

surrounded by five diminutive workers. While it is certainly remarkable that one does not find similar incipient colonies of our other Ponerinæ, this observation makes it probable nevertheless that the ants of this subfamily agree with the Componotinæ, Myrmicinæ and Dolichoderinæ in their method of founding colonies. Concerning the methods employed by the driver ants (Dorylii) and ants of visitation (Ecitonii) nothing is known. These remarkable insects are so secretive in all that relates to their household affairs that only time and lucky observation will be able to fill this gap in our knowledge.

* The *Pheidole* soldiers may leave the nest when needed as trenchers to carve the carcass of some insect that is too unwieldy to be dragged home by the workers. I have observed this in two of our smaller species, *Ph. vinelandica* Forel and *Ph. splendidula* n. sp. (allied to *Ph. metallescens* Emery). In the former case a caterpillar had fallen into a large ant-lion pit about three yards from the nest and had evidently been killed and partially consumed by the ant-lion. The carcass was covered with workers and soldiers busily engaged in cutting it into portable fragments. In

They are fed, groomed and guarded by the numerous workers of the colony and may therefore be said to live in a condition of domestication like the queens and males.

During the past three years I have had many opportunities to examine *Pheidole* colonies in different stages of growth, and my observations bear out the following general conclusions which agree with those advanced by Adlerz:

1. Both the morphological and color variations increase both absolutely and relatively in number as well as in amplitude with the increase in the number of individuals in the colony.

2. This increase in variability is also in direct proportion to the increase in the trophic status of the colony.

The truth of these statements will be apparent from a consideration of a few cases. The first offspring of the mother queen of a *Pheidole* colony consist of a few very diminutive workers only. The second batch of young, at least in one nest of *Ph. dentata* which I examined, were, with a single exception, also workers, though larger than those found in the earliest stage of colony formation. This single exception was a soldier, with a much smaller head than that of the typical soldiers of this species, and its coloration was that of the workers. In more advanced nests the typical soldiers make their appearance, at first a few, then more, till they are abundant in old and well-established colonies. But they never become as numerous as the workers, since the latter are being continually reared in considerable numbers during the whole life of the colony. It is easy to observe, without resorting to statistics, that the number and range in the color variations in both the soldiers and the workers keep increasing, and in polymorphic forms, like *Ph. instabilis*, the heads of the soldiers show a remarkable progressive enlargement and increased complication in the details of coloration and sculpture. I have repeatedly found incipient nests of this species containing only workers and the small-headed soldiers of different sizes, so that I was at first deceived as to the species of *Pheidole* I had before me. One nest, examined during the current year, contained only a single soldier of the extreme, large-headed type so characteristic of the species. Such soldiers appear in considerable numbers only in very large, *i. e.*, old nests, and it is only in such nests that one finds, during late May, the highest efflorescence of the colony, the hosts of males and winged females. The soldiers of the extreme type in *Ph. instabilis* assume a monstrous, one might almost say hypertelic, appearance, the head being so large in proportion to the body that it may lead to serious results to the insect. I observed that when one of these soldiers happened to fall on the back of its head in one of my glass nests, it was often quite unable to right itself, but stood on its head wriggling its tiny body and legs for hours till it could clutch at a passing soldier and thus regain its normal position.*

It is an interesting fact that the workers

another pit-fall in the same locality two large ants (*Camponotus sansabeanus*) were being treated in the same manner by the soldiers and workers of *Ph. splendidula*. These observations are suggestive in connection with the problem of 'communication' among ants.

* This observation suggested some experiments with isolated soldiers. When these are dropped on their heads from a little height on a smooth surface, like clean glass or polished wood, they are often quite unable to regain a footing. Many remain in this position for hours or even for two or three days, struggling at brief intervals and finally dying of hunger or fatigue. If a bottle, the inner surface of which is moistened with a drop of chloroform or alcohol, is placed over the insect, it is at first stimulated to the utmost exertion to right itself, but it often dies of suffocation without being able to turn over.

and soldiers of *Pheidole* species often vary independently of each other, in both form and coloration and it has long been known that this variation is not a correlative one, since the examination of many species has shown that it is impossible from a study of the soldier of a given species to predict the form, sculpture and coloration of the corresponding worker and *vice versa*. This is beautifully illustrated, so far as coloration is concerned, by the Texan varieties of *Ph. hyatti* Emery. In west Texas (San Angelo, Terlingua, etc.) both soldiers and workers are of a rich fulvous yellow. In central Texas, however, the workers are black or nearly so, whereas the soldiers may be yellow throughout, brown with pale yellow heads, or in other nests nearly or quite as dark as the workers. Not only do the variations among the soldiers become numerous and considerable only in older nests, but the same is also true of the workers. In large nests of an undescribed seed-storing species (allied to *Ph. pilifera* Roger), I recently found several workers (macroërgates) of the size and coloration of the soldiers, but without any tendency to increase in the size of the head or assumption of the sculpture of the soldiers.

Among the males and virgin queens, which do not make their appearance till the colony is mature—in some species of ants not till the second or third year after the colony is founded—we also find very pronounced variations. These are, of course, more significant, since they occur in individuals undoubtedly capable of reproduction. Here we must include the whole range of normal and pathological variations, such as the various transitional forms between the workers and queens (microgynes, pseudogynes, ergatoids, macroërgates) and the pathological transitions between males and queens or between males and workers (hermaphrodites, or gynandromorphs) as well as the normal males and queens of different sizes, structure and coloration. *It is a significant fact that all these variations, no matter how aberrant, are cared for and protected in the nest so long as they are capable of being fed.* They are enveloped by the general fostering instinct which is so characteristic of the worker ants, since it leads to conditions in such marked contrast to the well-known goring instincts of cattle and the weaker but nevertheless perfectly patent analogues among men. The following facts show that the motives for a tragedy like the *Œdipus Tyrannus* do not exist in ant-society. In one of my artificial nests there is a congenitally crippled worker of *Polyergus bicolor* Wasmann that is scarcely able to walk. Still for the past three months it has been carefully fed and cleaned by the workers of the enslaved species (in this instance, workers of two species, *Formica subœnesceus* Emery and *F. obscuripes* Forel). In the nest of a new species of *Leptothorax* I have seen a somewhat crippled lateral gynandromorph (male on the left side, with testis, worker on the right, with ovary!) that must have been fed and cared for by the workers as it was perfectly mature. Forel* describes a lateral gynandromorph of *Polyergus rufescens* that was moving in file with the normal workers and carrying a larva which it had pillaged. Here belong also the peculiar parasitized macroërgates which I described in a former paper.† These and many other cases that could be cited may perhaps make it easier to understand how monstrous neuter forms like the *Pheidole* soldiers could develop phylogenetically.

Several of the above mentioned variations, like the ergatoids and gynandromorphs, have not yet been observed in

* 'Fourmis de la Suisse,' p. 142.

† 'The Parasitic Origin of Macroergates Among Ants,' *Am. Natur.*, Vol. 35, 1901.

Pheidole species, but peculiar microgynes, or dwarf queens, certainly occur in some of the members of this genus. Emery* describes a dwarf deälated queen of *Ph. pilifera,* which was scarcely 3.5 mm. long. Normal queens of this species measure 6–6.5 mm. Emery's microgyne exhibited also an aberrant configuration of the epinotal spines. Recently Rev. P. J. Schmitt took two similar deälated microgynes in the nest of an undescribed *Pheidole* which occurs in Colorado and New Mexico. He kindly sent me one of these insects, which is smaller than any of the soldiers from the same nest. It measures only 2.5 mm., whereas a typical queen of the same species in my collection is 5 mm. long; and therefore eight times as large (in volume) as the microgyne. In this case the microgyne differs from the normal queen in color, pilosity and sculpture, so that had it been captured apart from the colony, it would certainly be regarded as the mother queen of a minute and very distinct species of *Pheidole.*

If it is true that the increasing variability exhibited by the *Pheidole* colony is the result of an increase in the number of its component individuals, and if this, in turn, may be traced to favorable trophic conditions, we should expect to find but little variation in colonies that are poorly fed and therefore unable to increase rapidly in number. This I find to be the case. In central and western Texas during the past autumn and winter the meteorologic and food conditions were extremely unfavorable, not only to ants, but to insects in general. Between September and the latter part of March almost no rain fell, and the protracted drought together with the cold of the winter months was very trying even to the ants that feed on stored seeds. During this period the number of soldiers in the *Pheidole* nests was found to be unusually small. In some nests of considerable size (*Ph. dentata*) they were entirely absent. One might suppose that the soldiers had died off on account of the unfavorable conditions, but this is improbable, because the vitality and hence also the longevity of the soldiers is superior to that of the workers, just as the vitality of the queens is much superior to that of all the neuter forms and the males.* I am therefore of the opinion that the scarcity of soldiers in the *Pheidole* nests was due to their not having been reared by the workers on account of insufficient food, moisture and warmth. Thus there was a tendency to suppress even the normal dimorphic variation of the neuter phase.

A peculiar Texan *Pheidole* (*Ph. lamia* Wheeler) may also be adduced as evidence of the inhibitory effects of unfavorable conditions on variability. *Ph. lamia* is a very small, timid species which lives a subterranean life under stones and feeds on dead insects, myriopods and crustaceans somewhat after the manner of the diminutive 'thief-ants' (*Solenopsis molesta* Say and *S. texana* Emery). It has the pale yellow coloration so characteristic of hypogæic species. Its very small colonies contain barely fifty individuals, and though I have found some eight or nine nests of this rare species in different localities and

* 'Beiträge zur Kenntniss der nordamerikanischen Ameisenfauna,' *Zool. Jahrb.,* Abth. f. Syst., 1894, p. 290.

* This is easily proved by observations on artificial nests that have not been supplied with the requisite food and moisture. In a nest of *Myrmica brevinodis* Emery which on September 14, 1901, contained forty virgin queens and five times as many workers, thirty of the queens but only two workers were still living March 14, 1902. *Myrmica brevinodis* lives in cool New England bogs, and it was difficult to maintain the right amount of moisture in the nest at all times during six months of very dry Texas weather. In this connection see also Lubbock's notes on longevity in ants ('Ants, Bees and Wasps,' pp. 41, 42).

have been able to capture the entire colonies, I have found in each case only a single soldier. This individual is of extraordinary aspect, its huge, cylindrical head being unlike that of any known species of *Pheidole*. In none of the nests have I been able to find a queen. As the abdomen of the single soldier is relatively larger than in other species of the genus, it is possible that this singular individual may produce eggs and thus replace the winged queen as the mother of the colony. The colonies of *Ph. lamia* certainly present a miserable appearance when compared with the teeming colonies of other species, and it is difficult to avoid the conclusion that the small size of the colony, the suppression of all but a single soldier and the possible elimination of the queens, are the result of unfavorable conditions. This ant is, I believe, really an effete or evanescent species, a species in what Hyatt called the phylogerontic stage.

Although many additional observations both of species of *Pheidole* and of other genera could be given, I believe that enough evidence has been presented to show that ants normally live under conditions eminently favorable to the production of variations and the preservation of these in the sexual forms till the latter are able to meet the exigencies of the struggle for existence with the best endowment of vigor and nutrition. We should therefore expect the ants to display a high degree of variability, and this is fully borne out by a study of these insects as a family in the taxonomic sense. Up to the present time the ants alone of all invertebrate animals have been successfully treated in taxonomy like the birds and mammals. The trinomial and quadrinomial nomenclature in the hands of Professors Emery and Forel admirably expresses the fine shades and relative stability of the form and color variations which can be recognized in these insects. It is safe to predict that a quinquenomial system may be necessary before long adequately to symbolize the still more delicate subvarietal deviations observed in different nests of the same varieties.

The importance of this high variability or plasticity from the standpoint of the development of instincts and intelligence, and in fact in all those life-activities which may be conveniently designated as *ethological*,* must be apparent on a moment's reflection. In my opinion the manifold and often wonderfully perfect morphological and psychological adaptations, which have made the ants the dominant group among terrestrial invertebrates, have their origin in the variability so greatly enhanced by the production of enormous numbers of individuals and the care and protection afforded, through a most important period of their lives, to the reproductive individuals of the colony. This is true no matter what views we may hold on the subject of selection since, so far as the substance of this paper is concerned, it may be immaterial whether we demand that there shall be many simultaneous variations of the same kind, that the variations shall be saltatory, gradual, determinate or indeterminate, whether we pin our faith to 'orthogenesis' or to Darwinism in its original form, to coincident ('organic') or to germinal variation. Any or all of these forms of variation may exist in the fully developed ant colony and, in all probability, also during the great periodic increase in numbers exhibited by many other animals.

William Morton Wheeler.

University of Texas,
March 19, 1902.

* In a forthcoming paper I hope to justify the use of this term as it is employed by some French zoologists in the place of the less satisfactory 'ecology,' 'natural history' and 'Biologie' in the German sense.